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More efficient integration of intermittent renewables and distributed generation in the European electricity supply

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More efficient integration of intermittent renewables and distributed generation in the European electricity supply

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Contents

- Drivers for more intermittent renewables, wind, PV, micro-CHP in future
- Impacts on different segments of power system, mainly markets & networks
- Options to mitigate negative system impacts
- Conclusions for system improvements

Drivers for more renewables and DG

Greenhouse gas emission reduction

- **EU Kyoto target** : -8% reduction in 2008-2012 compared to 1990 emissions
- CO_2 emission reduction in 2020: -20% (or even 30% pending post-Kyoto outcome)

Renewable electricity

- 2010 target: 21% electricity demand in EU from renewable sources
- **2020 target**: share of **RES 30-50% in electricity** and 20% in total primary energy supply

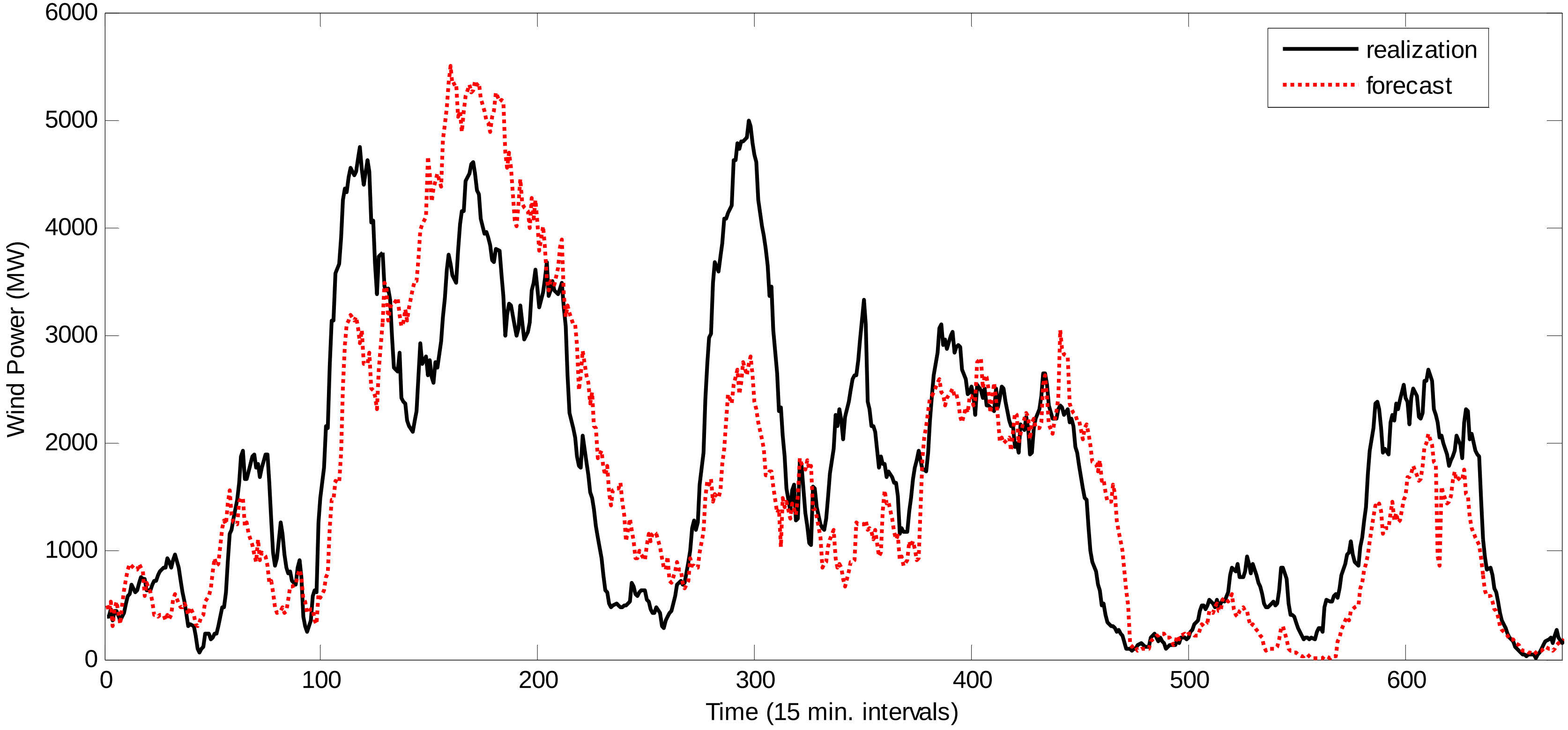
Energy efficiency

- EU directive for **Combined Heat and Power** (CHP)
- EU Action Plan for Energy efficiency: 20% energy saving by 2020 compared to baseline

Enhancing supply security by reducing fuel dependency

→ Support Schemes in Member States

Example of wind intermittency in Netherlands



Forecasted (red) and realised (black) wind power production in a week in the Netherlands by extrapolating output of current plants to 6000 MW off-shore and 1800 MW onshore

***Conclusion**: wind imbalance requires flexibility at time scales of a few hours*

Main features of negative impacts large scale intermittent renewables

- A higher share of intermittent renewables implies a more variable, and less predictable and controllable supply of electricity

→ e.g. more demand for **flexible** generators

- A higher share of RES-E leads to more expensive network operation (voltage rise effects, increased fault levels, energy losses)

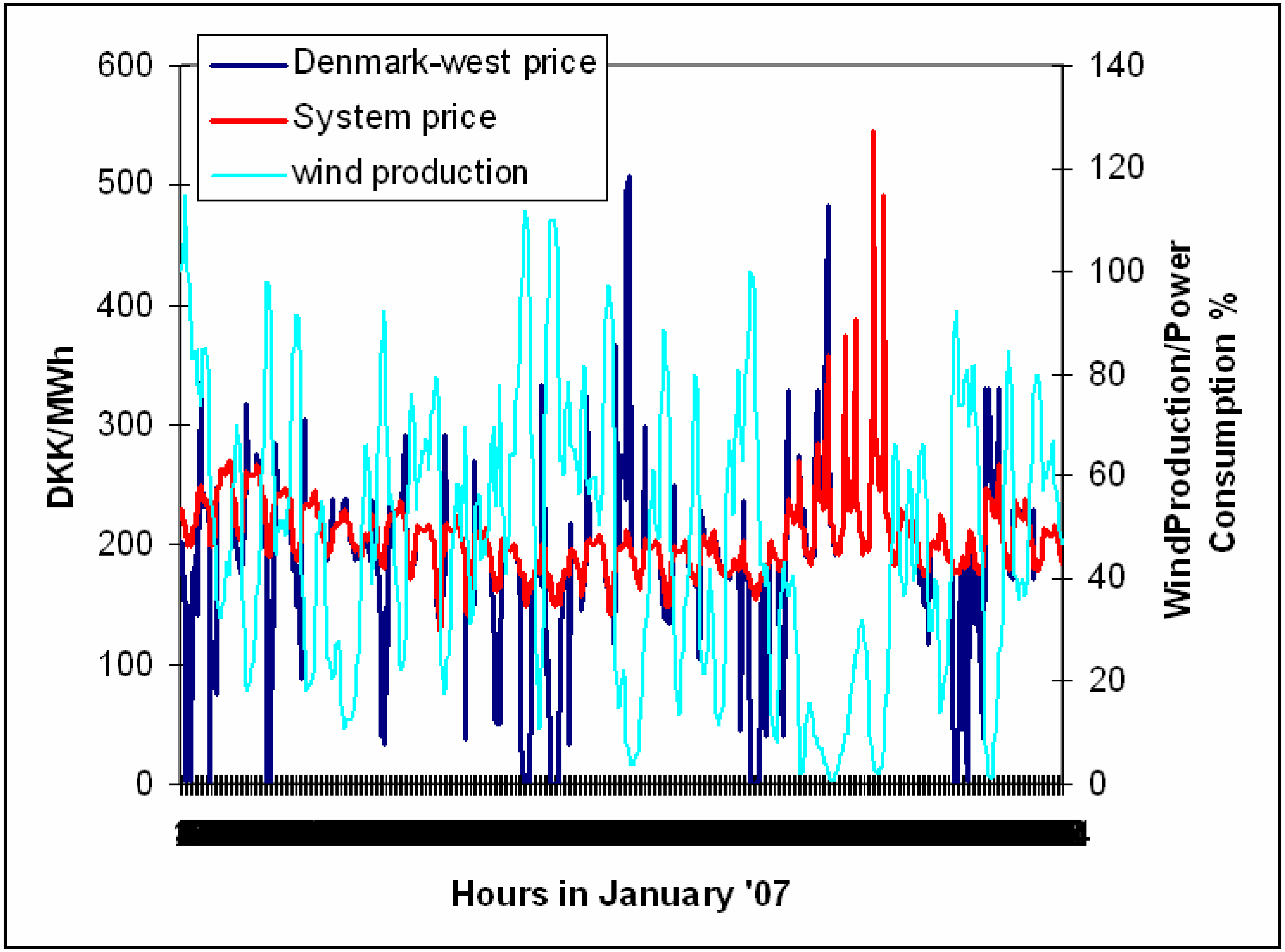
→ e.g. more demand for technical and economic measures for network **controllability**

Cost impacts of intermittent renewables

- Markets
  - Lower revenues for base load generators and higher revenues for peak load generators
  - Higher price volatility

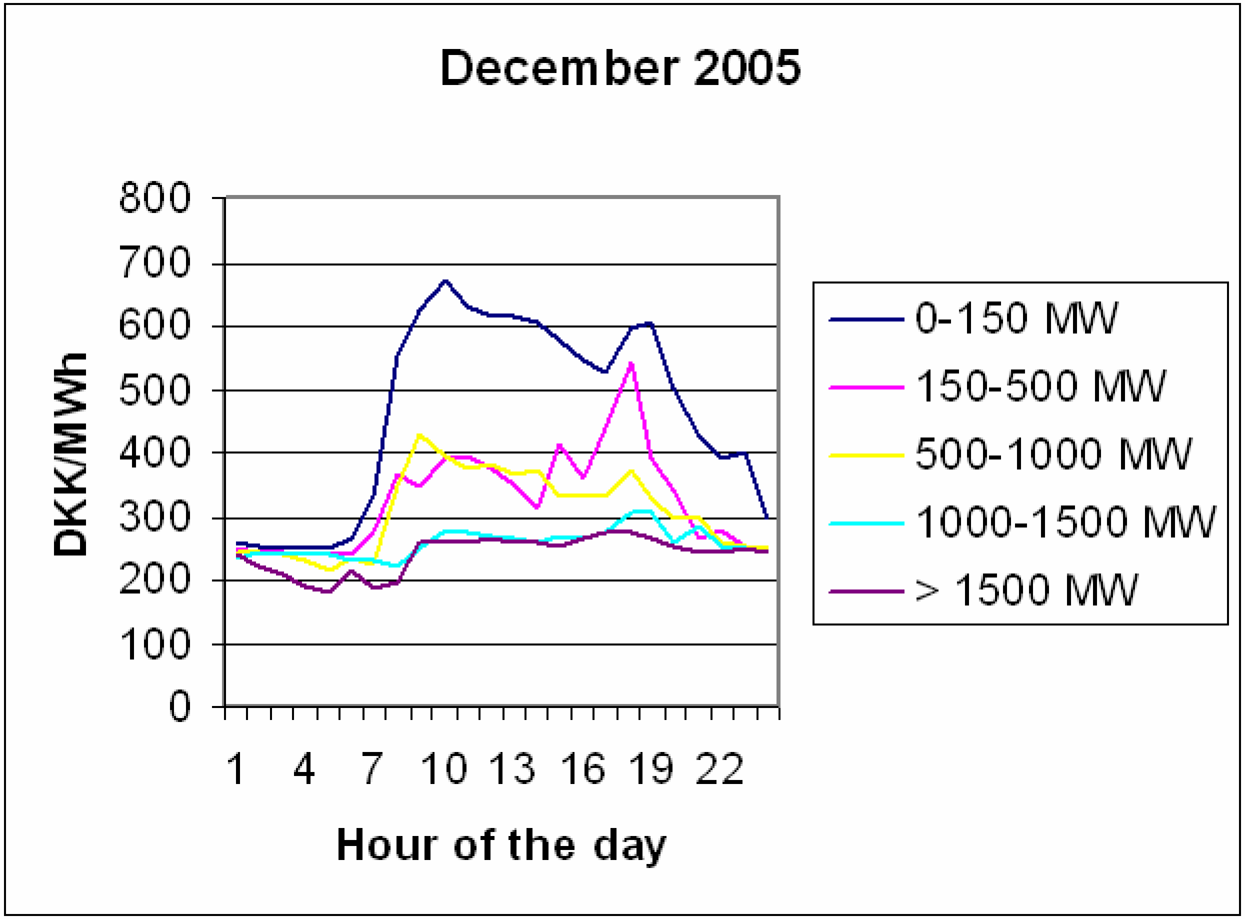
- Networks
  - Higher balancing costs
  - Higher network costs due to network reinforcements and in some cases more energy losses

Impact wind on spot price West-Denmark



Source: Poul Erik Morthorst (100 DKK ~ 13 EUR)

Impact wind on spot price West-Denmark



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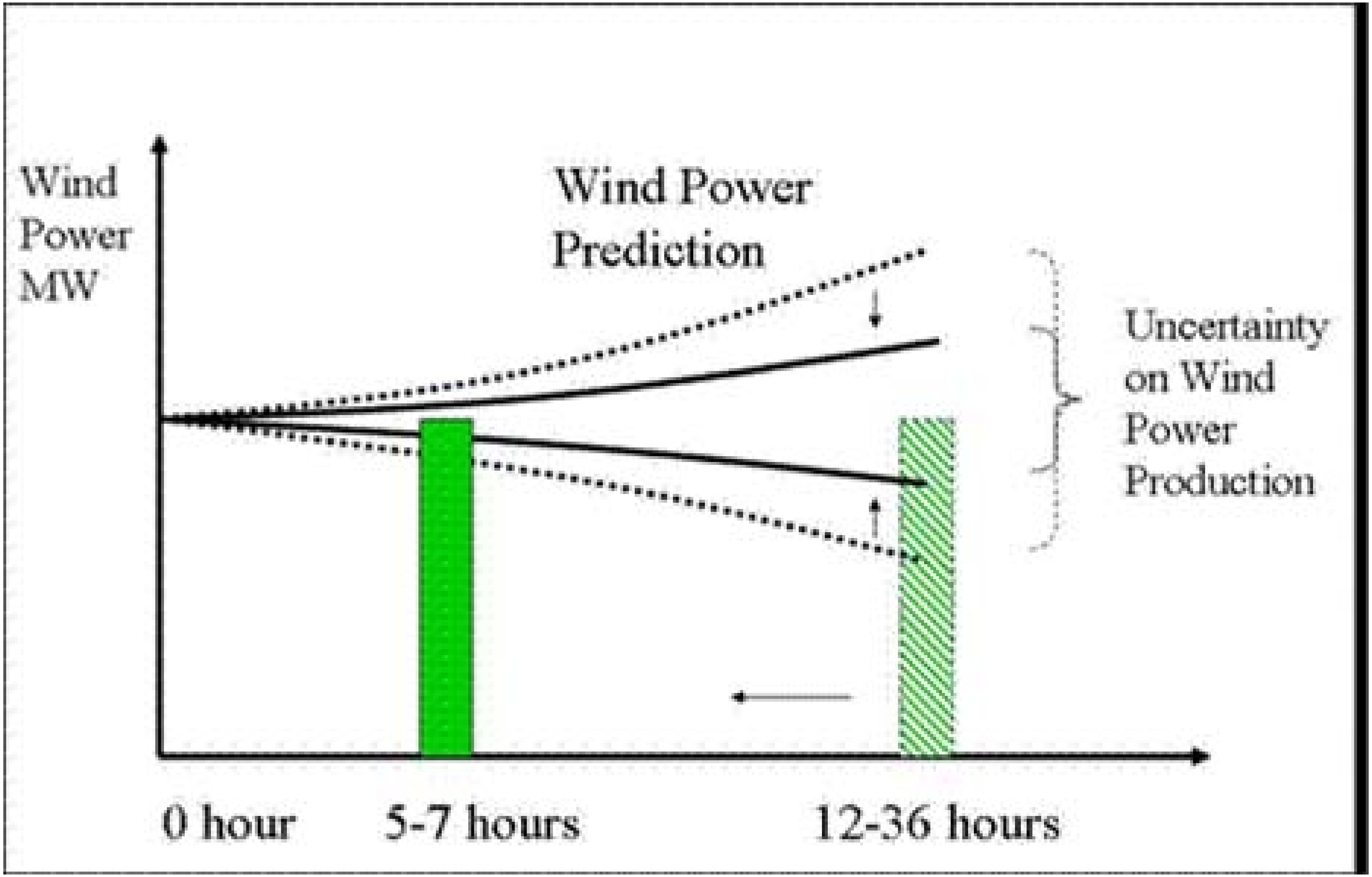
Earlier gate closure time and improved wind forecasting reduce uncertainty in wind power estimates



Options for reducing price variations in systems with a large share intermittent renewables

- Reduce effects of power output variations
  - More interconnection capacity
  - More flexible generation
  - VPPs by pooling different generation

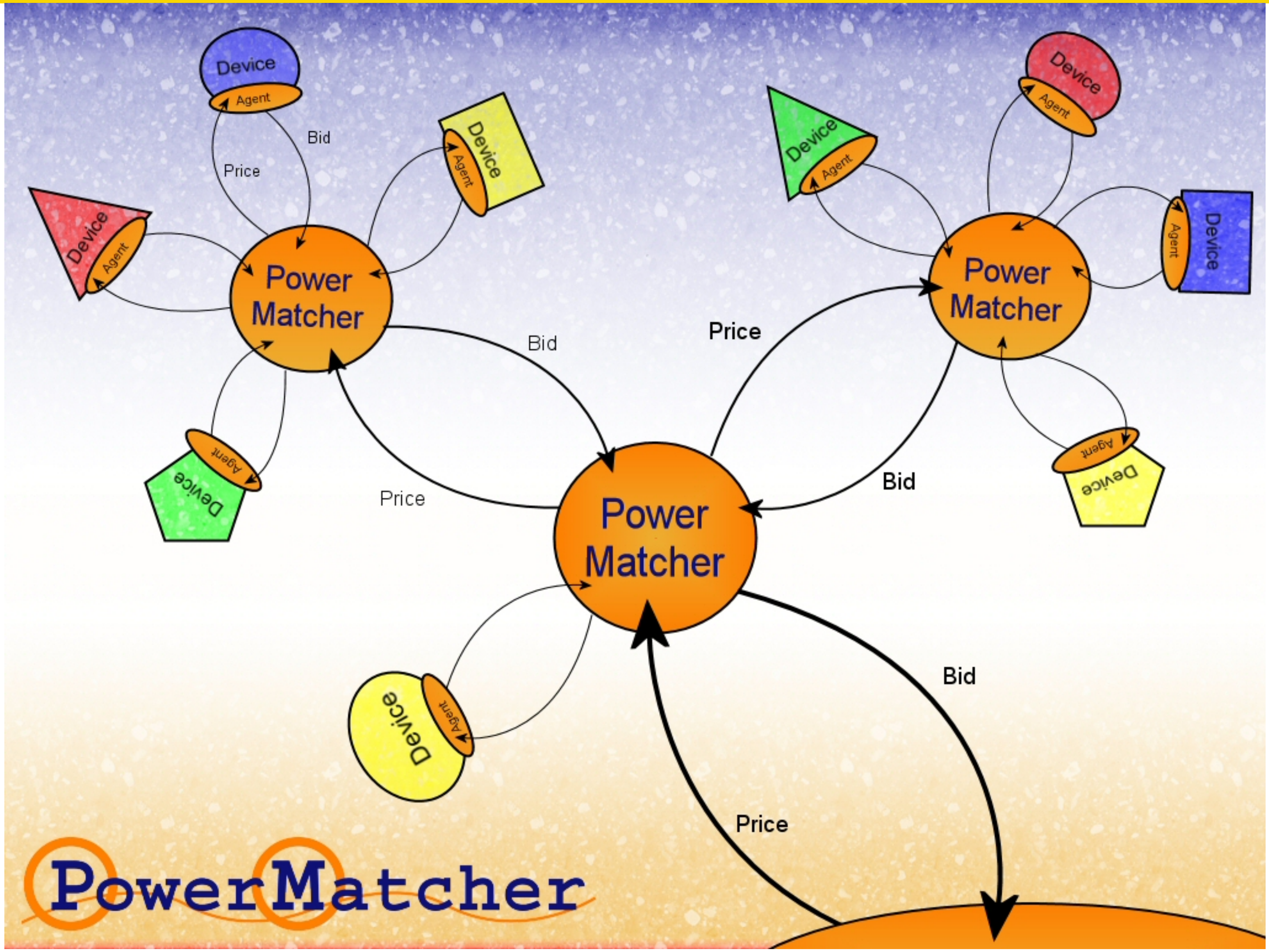
- Demand options
  - Increase price sensitivity consumers
  - Storage
  - Interruptible contracts (reserve capacity; congestion management)

Options to reduce impacts on networks, DSO & TSO

- Technical options:
  - Active network management (DSO)
  - **Storage (TSO, DSO)**
  - Demand response (DSO)
  - More interconnections (TSO)
  - Improved wind power output forecasting (TSO)

- Economic/commercial options:
  - **Virtual power plants (TSO,DSO)**
  - Time of use network tariffs (TSO, DSO)
  - Locational network tariffs (TSO, DSO)
  - Interruptible contracts (TSO, DSO)

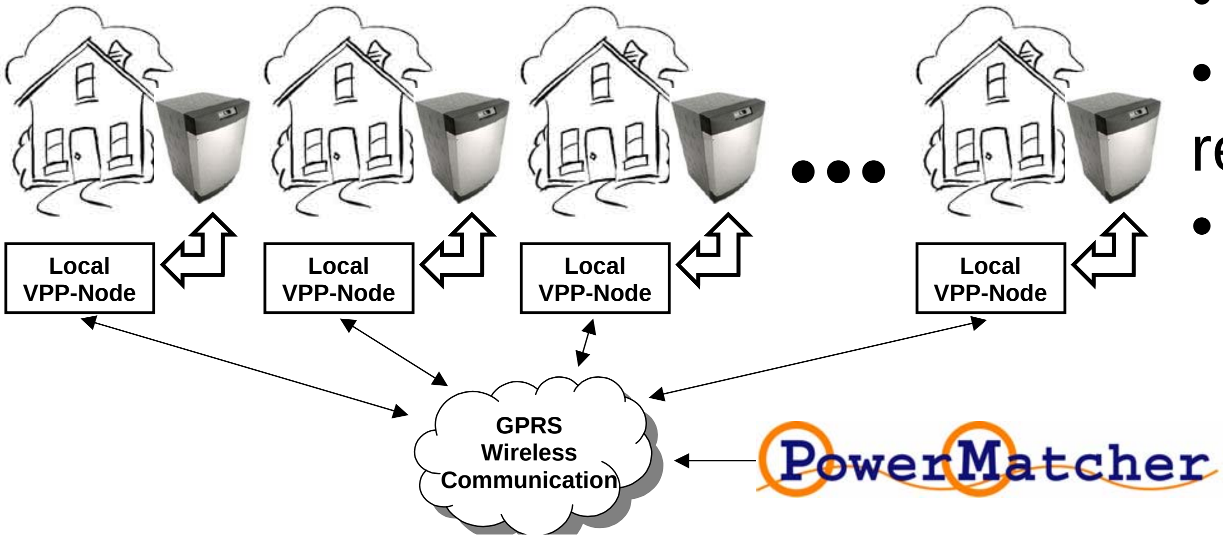
Active network management with a Virtual Power Plant (VPP)



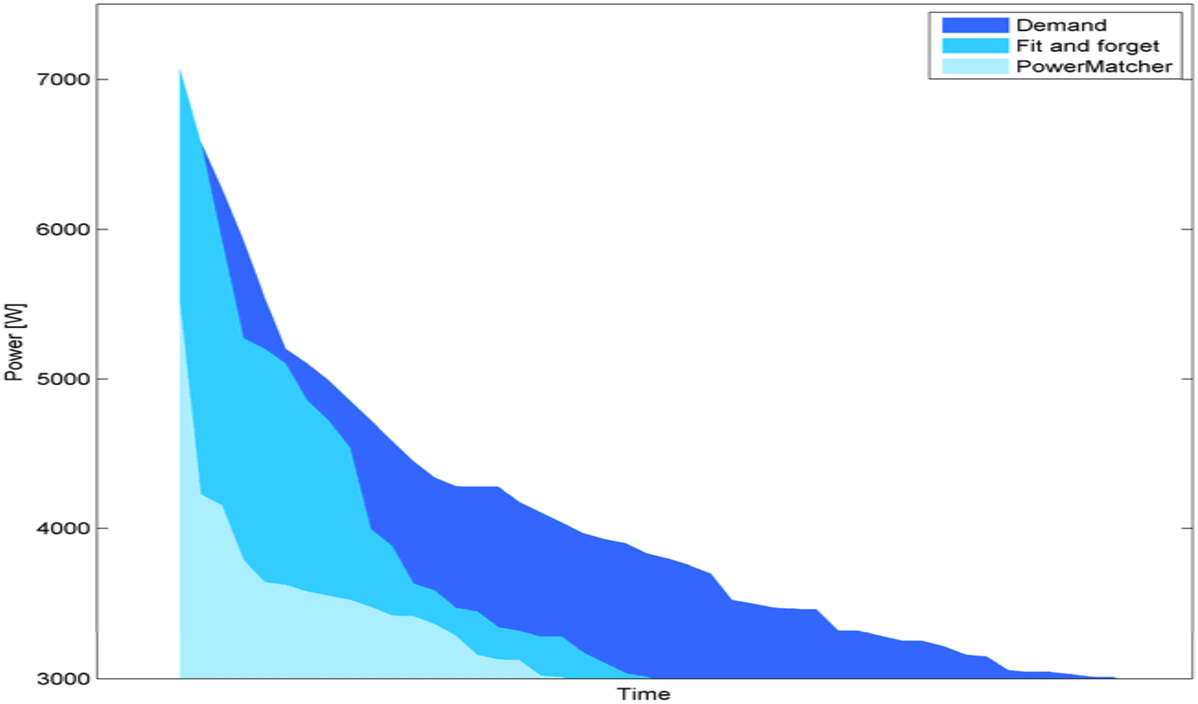
VPP = Solution on technical and organizational level to efficiently mobilize large number of small flexible generation and demand response

Field Test VPP for Active Network Management
VPP with residential micro co-generation

- 10 Households
- Micro-CHP for heating
- Objective: Peak load reduction in network
- No loss of user comfort



μCHP Virtual Power Plant Field Test:
effect of intelligent control on load-duration curve



1. No CHP: original load duration curve
2. “Fit and Forget” (no control): No reduction transformer peak load.
3. PowerMatcher:
   - 50% peak reduction (winter)
   - 30% peak reduction (summer)

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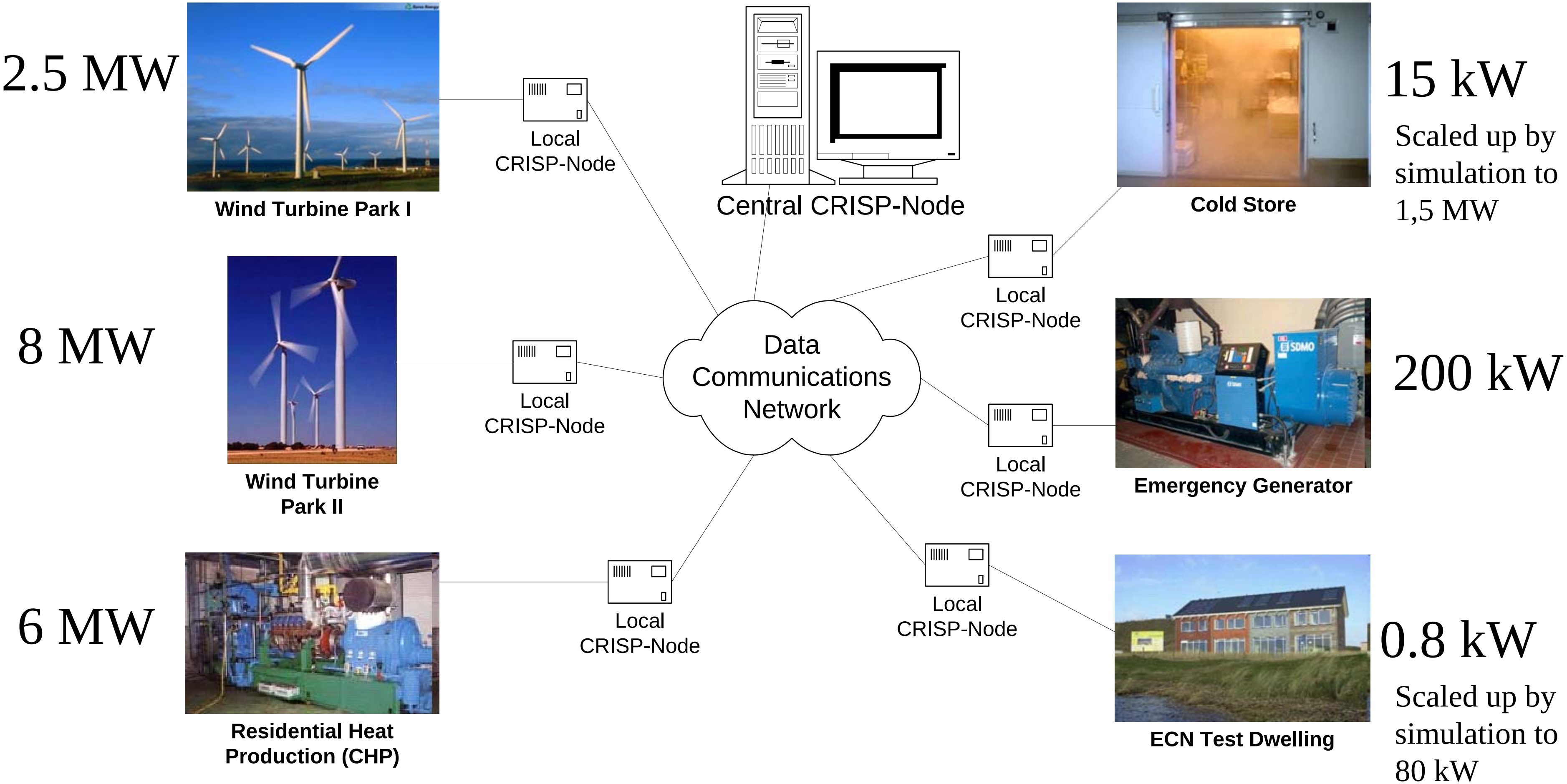
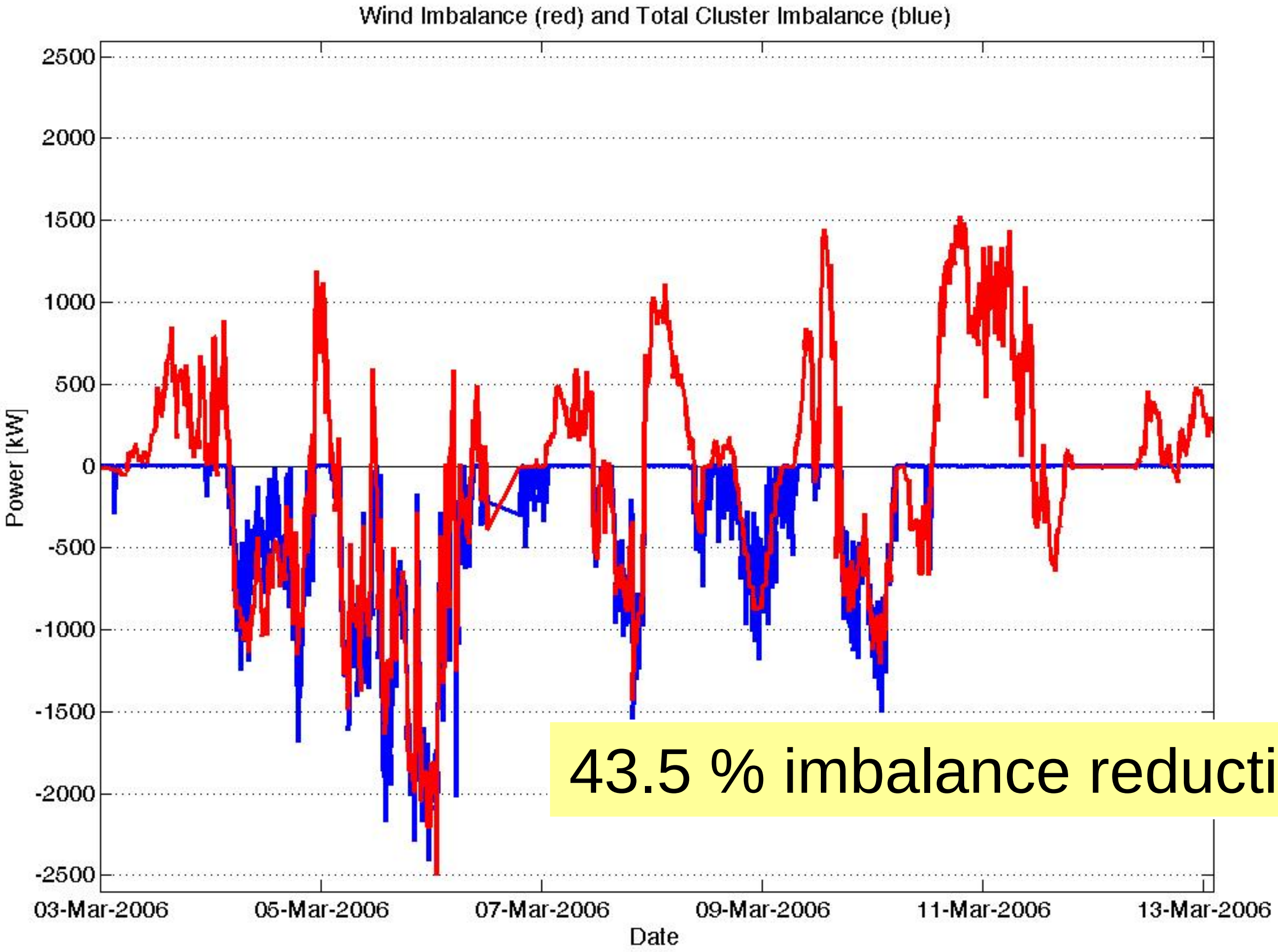
Field Experiment:
VPP for reduction of wind imbalance in a portfolio

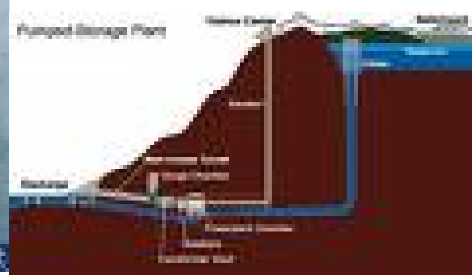


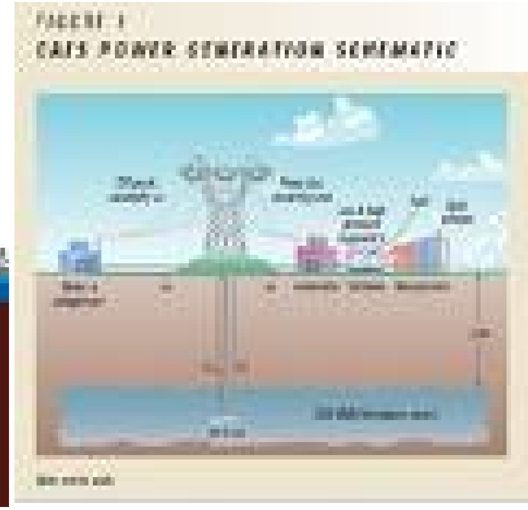
Wind induced Imbalance and Cluster Imbalance



43.5 % imbalance reduction

Storage and interconnection options Netherlands

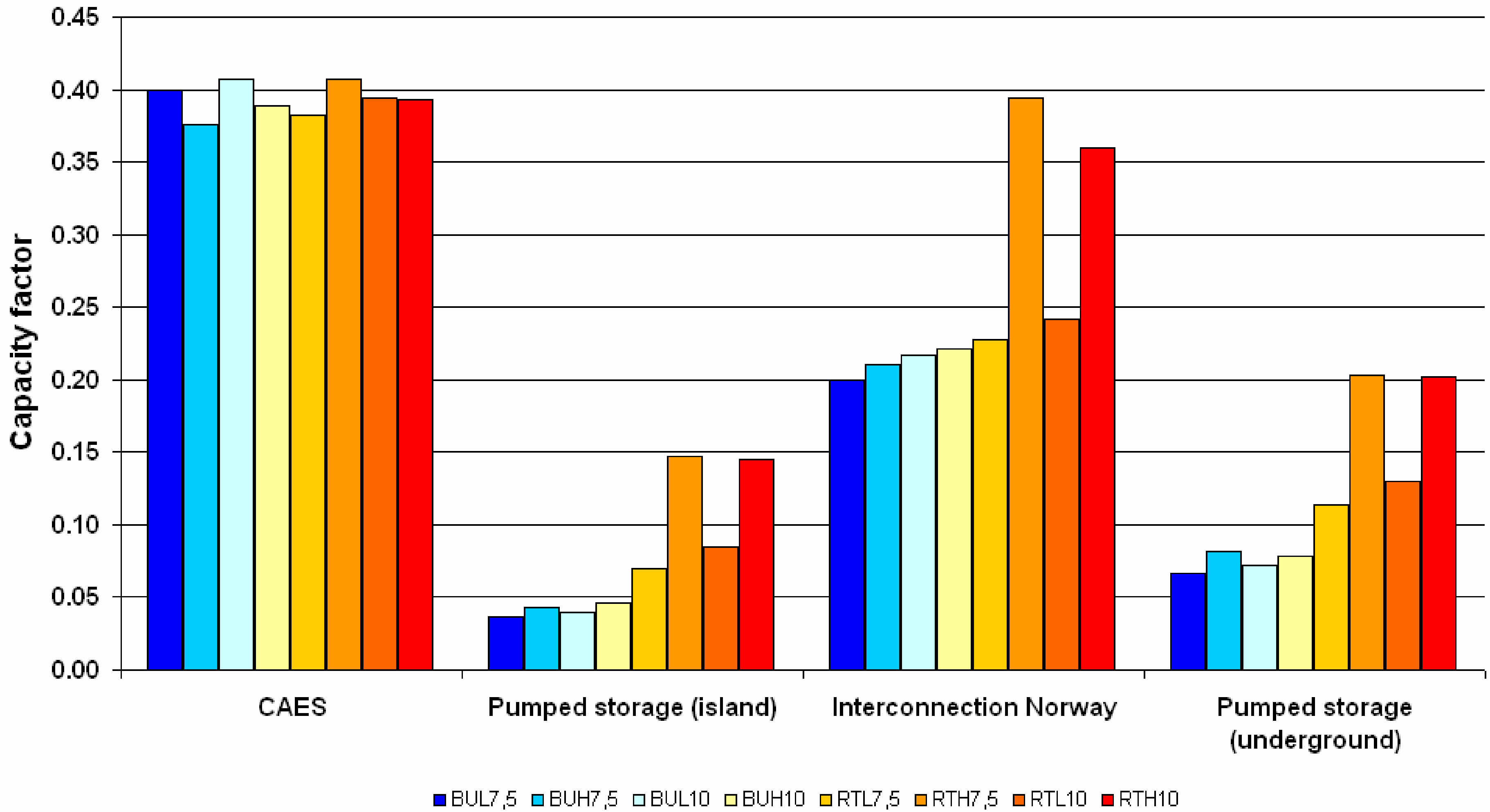




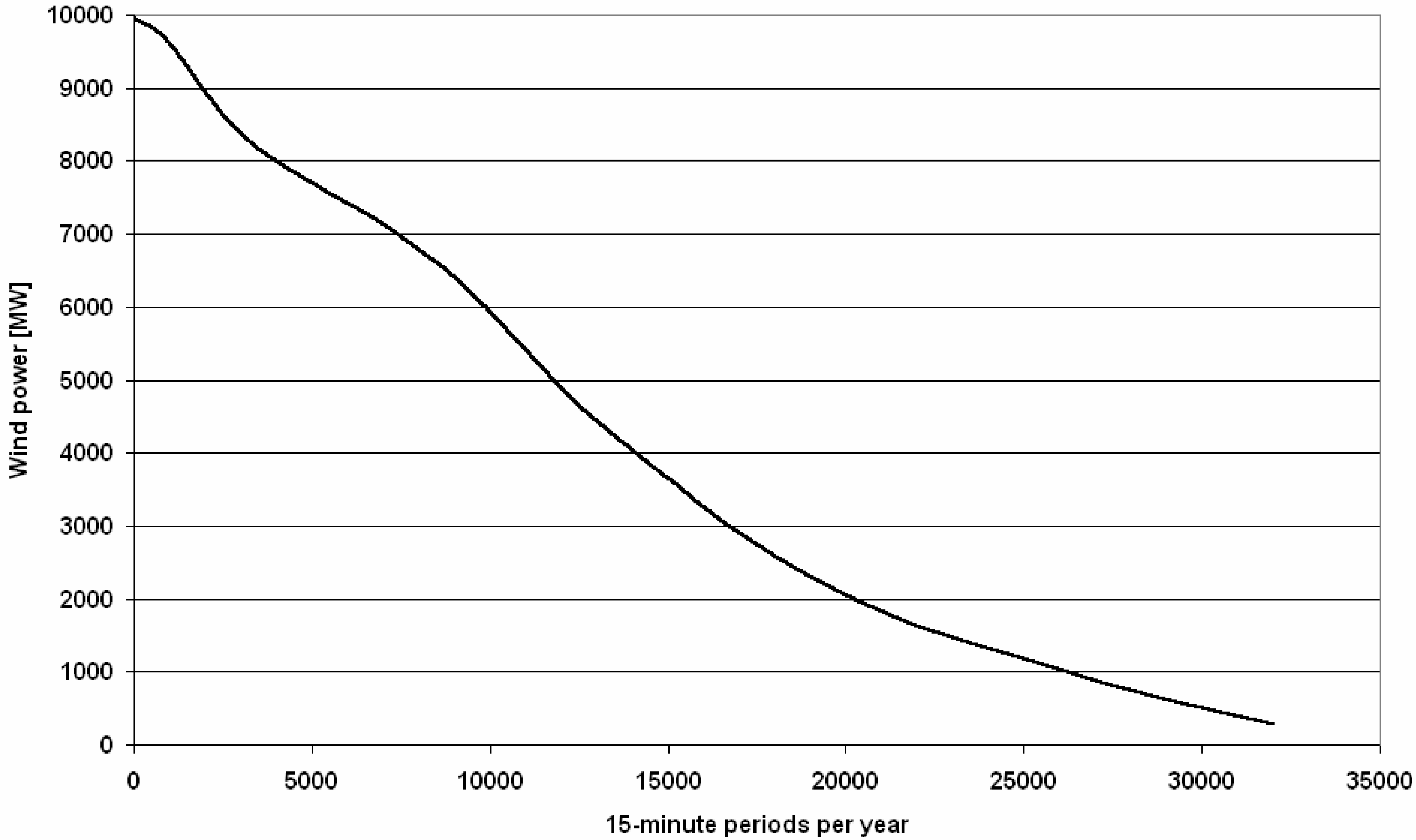
3 storage options compared with additional interconnection:

- Pumped storage (energy island) (1670 MW, 20 GWh)
- Pumped storage (underground) (1400 MW, 16 GWh)
- Compressed air energy storage (1500 MW, 20 GWh)
- HVDC interconnection with Norway (1400 MW)

Simulation: capacity factors of storage and interconnection Netherlands



Annual wind power duration curve 10,000 MW in the Netherlands



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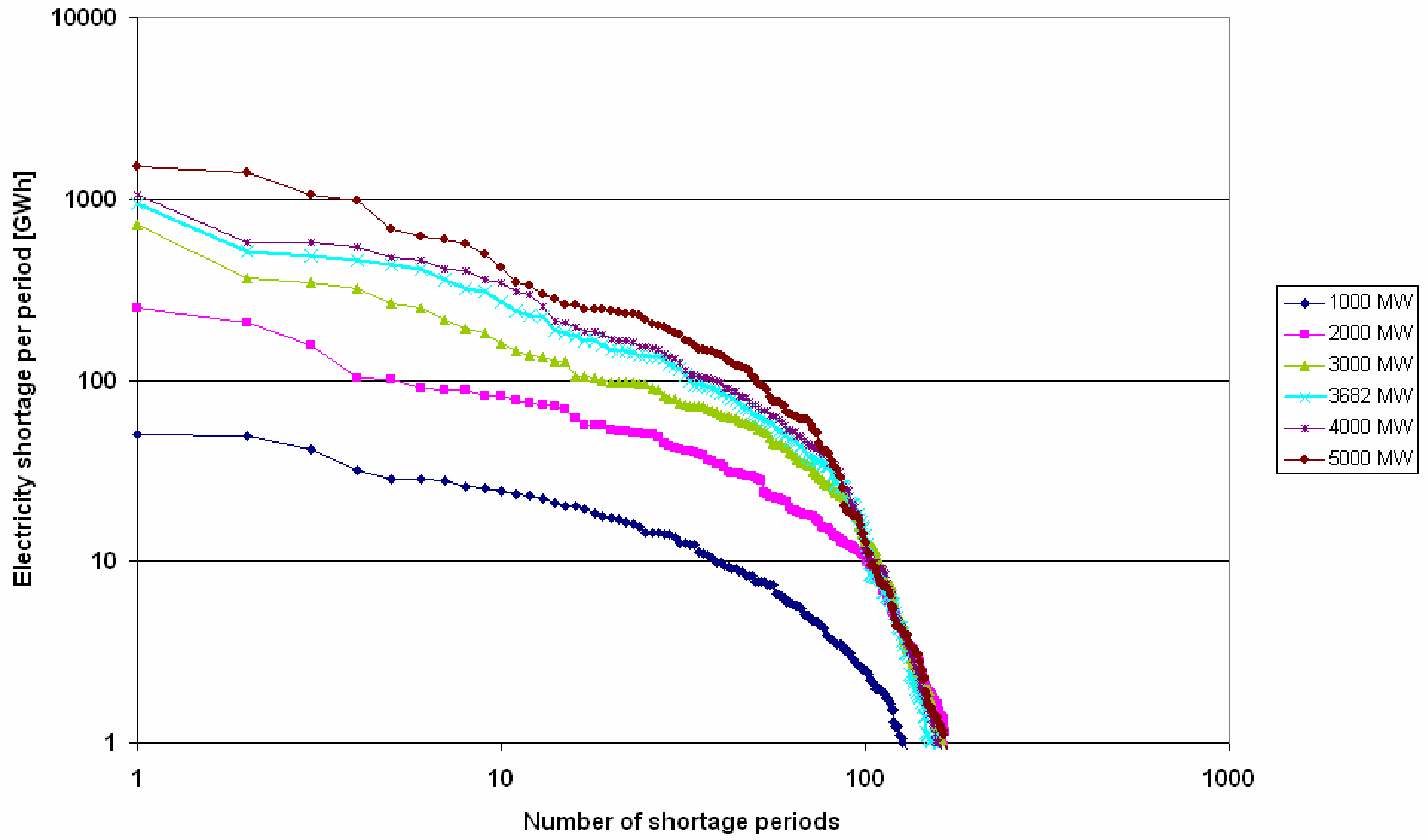
10,000 MW wind in the Netherlands Frequency and duration of periods with wind output below 1,000 – 5,000 MW



Example: A 20 GWh storage system + 10 GW wind is insufficient for 16 periods per year to meet a minimum continuous power level of 1000 MW. Maximum shortage: 50 GWh

Storage + wind combination

- Large-scale storage: under-utilized most of the time (low capacity factor)
- Small amount of storage: in-sufficient capacity to compensate longer periods of low wind
- Storage will not be the only/major flexible component to reduce impacts wind intermittency due to difficulties in handling longer periods of low wind

Small-scale storage in Plug-in Hybrid EV

- A PHEV is a hybrid vehicle with a larger battery to allow longer distances electric driving
- Charging can be done intelligently: ideal demand response technology
- Vehicle to Grid (V2G): part of the time acting as a source of electricity
- Storage to support the grid provides additionai benefits and doesn’t have to cover the full battery costs
- Small scale storage systems can provide a flexible response to wind intermittency problems at time scales of around one hour

CONCLUSIONS

- Conventional generation capacity (coal, gas, hydro, biomass,….) is needed as back-up to meet longer periods of low wind power (days and longer)
- Stronger interconnections reduce impact of intermittency because effects are averaged over larger areas
- Intermittency at scale of hours can addressed by:
  - Demand response
  - Small storage systems with fast charging/discharging

More efficient integration of intermittent renewables and distributed energy resources in European electricity markets will require the following priorities:

- Stronger interconnections
- More effective demand response
- Small-scale storage to meet intermittency at time scales of hours

Questions?